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Public Committee to Increase Human Capital in High-Tech Recommendations for Education

An abstract based on the report of the committee chaired by Dadi Perlmutter, October 2022

In its guidelines, the outgoing government of Israel (Bennett-Lapid) determined to increase the rate of employees in the Israeli high-tech industry from 9% to 15% by 2026. To realize this goal, the government appointed an inter-ministerial committee of experts with the participation of business, academic, and philanthropic leaders. Chaired by Dadi Perlmutter, formerly vice president of Intel, the committee utilized research data gathered by the Aaron Institute and data from various government ministries. In its final report, the committee devoted considerable space and depth to the area of education. The committee's recommendations were adopted and authorized for execution by the government.

Recommendations for Education

1. The Ministry of Education should define a new study track in high school ("tech matriculation") which combines five units in mathematics, English, physics, and/or computer science. This combination of study tracks was found to significantly increase the potential of obtaining a research and development position in the high-tech industry.

2. The Ministry should adopt measurable targets related to the number of high school students completing a "tech matriculation" (from 9% to 15% by 2028), with special emphasis on increasing participation among certain population groups (female students — from 7% to 13.5%, Arab students — from 6% to 12%, and students in the periphery — from 9% to 14%).

3. Middle school excellence tracks should be significantly expanded (with an emphasis on "Science-Technology Cadre" classes) and targets should be set for their scope and diversity and for providing incentives to schools to open classes in middle school as well as study majors in high school, and for creating smooth transition between them.

4. Skills found to be necessary for the modern labor market, in general, and for the high-tech industry, should be incorporated by the education system into the curricula of relevant subject areas; chief among these skills are solving complex problems, teamwork, and independent learning.

5. The Ministry of Education should expand the path for career changers coming from high-tech to teaching, promote and expand integrated digital learning programs and online schools in the "tech matriculation" fields, and programs in non-formal settings that cultivate the above skills.

6. A program should be formulated to expand English-language studies to cover communication skills, which include written and oral presentations of complex arguments and the ability to conduct a discussion. Research has found that Israeli high-tech requires these skills, and they are beyond what is currently learned in the five-unit study track in English.

What are the Skills needed to work in High-Tech?

An abstract based on research by the Aaron Institute for Economic Policy

A research team, led by Zvi Eckstein, Niron Hashai, Ronen Nir, and Sergei Sumkin surveyed the characteristics of high-tech workers in Israel through the analysis of a comprehensive dataset of the Central Bureau of Statistics. In-depth survey of 600 high-tech workers in Israel complemented the quantitative data. The goal of the study was to point out to the current competencies and skills needed for various positions in the Israeli high-tech industry.

Main findings

1. During the last four years (2017 to 2021), there was a dramatic increase in the number of Israeli high-tech workers (from 285,000 to 390,000). The significant growth is mostly in R&D positions and among young people (under age 34).

2. Parallel to high-tech companies, there is significant growth in the number of people with digital skills in workplaces where they use their technological capacity to help optimize work processes (in banks, insurance companies, etc.).

3. The majority of those who work in R&D positions majored the "high-tech matriculation" package in high school. This package is a combination of study majors that includes five units each in mathematics, English, and physics and/or computer sciences.

4. Among high-tech workers, and likewise among university engineering students and "high-tech matriculation" high school graduates, the is an over-representation of Jewish males from affluent backgrounds. The researchers recommend that the education system act to increase and diversify "high-tech matriculation" graduates.

5. The research study also identified skills required by high-tech workers, such as: the ability to resolve complex problems in conditions of uncertainty, capacity for independent learning, and teamwork skills. The researchers recommend that the education system incorporate these skills into the curriculum.

6. The research identified a positive correlation between students in the "high-tech matriculation" track and participation in non-formal education frameworks, such as enrichment in science, sports, and youth movements. Additionally, the importance of the ability to communicate, present and debate in English, was identified.

Workers with a high school "high-tech matriculation" certificate which includes a combination of five units each in mathematics, English, and physics and/or computer sciences — 9% of students taking the matriculation examinations:

- 19% of Jewish (non-Haredi) boys and 12% of Jewish (non-Haredi) girls
- 12% of the Jewish boys and 7% of the Jewish girls who live in the periphery
- 6% of the Arab boys and girls
- 0.4% of the girls and boys in Haredi Schools

What Type of Mathematics Should Be Taught in Secondary Schools?

An abstract based on an expert report by Prof. Roza Leikin,
Prof. Dina Tirosh, and Prof. Avi Berman

In many countries around the world, mathematics curricula have undergone significant changes in recent decades. Among the factors contributing to these changes are the advances in scientific research in mathematics education; trends of the global world in which mathematics plays a central role; and the influence of international standards. The objective of this study was to analyze these changes in light of the Israeli mathematics curriculum in secondary schools, and to formulate a consensus report among well-known experts from various research institutions in Israel and abroad, to serve as a basis for an upcoming modification of the Israeli curriculum.

Recommendations:

1. The learning of mathematics in secondary schools should rely on three axes: knowledge, thinking, and reasoning Each dimension can be studied on a different level, in accordance with the learning stage or topic studied. Progress is made in a linear and spiral manner.

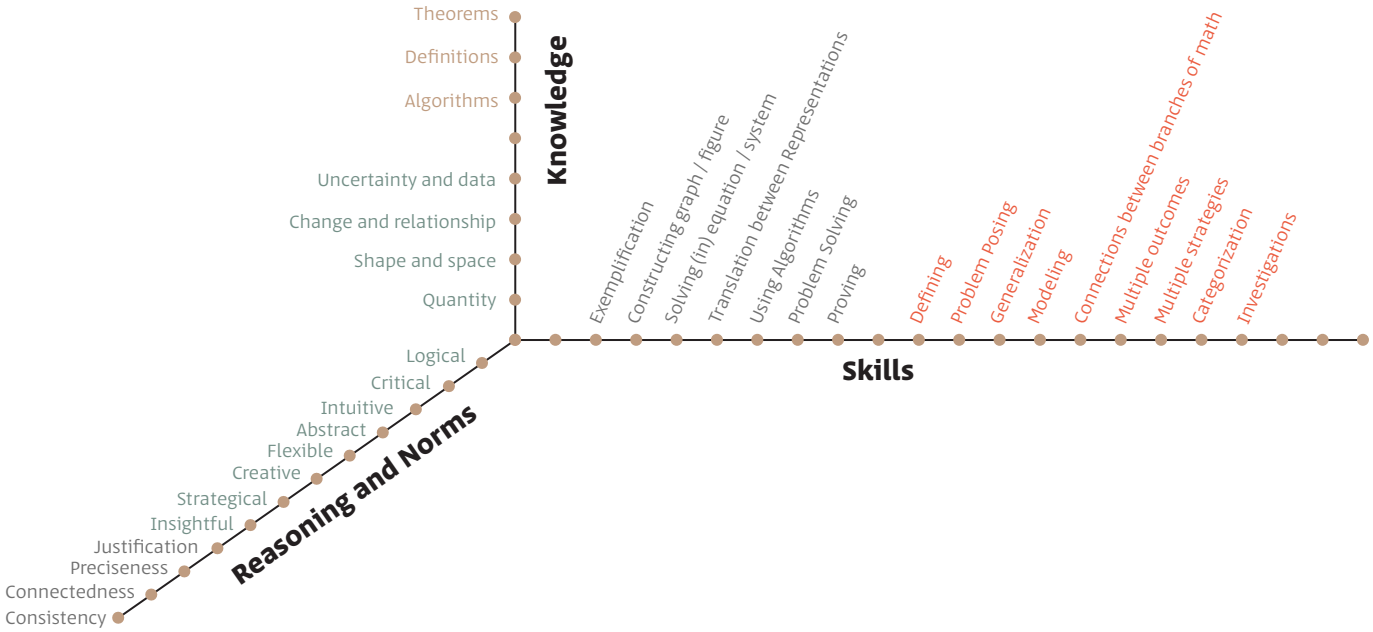
2. The knowledge axis: facts, concepts, definitions, theorems, and processes around content areas, such as geometry, algebra, and others. There is a certain degree of correspondence between the mathematical topics studied in the Israeli curriculum and those measured by international standards.

3. The thinking axis: types of thinking, such as logical, intuitive, critical, and abstract, practices by using proof, problem-solving, generalization, modeling, and research skills. At the high levels (5-6 PISA levels), students are asked to creatively devise new solutions to complex problems.

4. The reasoning axis: the ability to express the mathematical process by using consistent and precise arguments, while connecting the mathematical model to the real-world context. The higher the reasoning ability, the higher the level of mathematical learning in the classroom.

5. An initial mapping of the Israeli curriculum shows that at present, the main emphasis is on the knowledge axis and on the procedural and conceptual comprehension dimensions of the thinking axis.

Mathematical Thinking in School



To the full report

Israeli Students' Performance on the PISA Assessment in Mathematics

An abstract based on analysis by Zbigniew Marciniak and Agnieszka and Antonina Sotveska

The researchers accessed the international PISA assessment database and analyzed the performance of Israeli students for the years 2006-2018. The goal was to identify strengths and weaknesses, both with respect to mastery of mathematical concepts and technique, and aspects of thinking and reasoning skills. The importance of the study is to provide Israeli decision makers with an in-depth picture of the extent to which Israeli students are prepared for the current era in which people are required to solve surprising and complex problems that require creative mathematical thinking.

Main findings

1. Israeli students have a good command over mathematical technique, but have much difficulty in translating a problem from a real-world context to a mathematical model or language, and also have difficulty in evaluating the significance of the mathematical results and their implications for resolving the real problem. The researchers hypothesize that this is because most of the practice in school is devoted to formal procedures.

2. Israeli students have special difficulty in the field of "space and form" (geometry). PISA examines the transition between the physical world and geometric models vice versa. It appears that this particular transition presents a unique and even unusual difficulty for many Israeli students.

3. Israeli students tend to "skip" many questions that present them with the need to cope with problems they have not previously encountered. When ae problem requires independent thinking and courage, they are fearful and give up quicky.

4. The researchers believe that Israeli policy makers may want to consider the following steps:

- **a.** The Israeli curriculum should give substantial place to literacy skills, mainly in the field of geometry, and allow teachers and students a creative space for transitions between context, concept and model.
- **b.** The high rate of skipping questions signals a possible lack of readiness for independent mathematical thinking and absence of courage to contend with unfamiliar situations. Therefore, teachers should stimulate open and flexible discussions in class and not focus only on standard solutions to problems.
- **c.** Classroom pedagogy in mathematics lessons in Israel should change. Students should be given more time to think, cope, experiment, make mistakes and to reach the solution on their own. The teachers should arouse the belief among students that they have the capacity to solve any complex problem.

To the full report

Evaluation of the Foundation's Portfolio of Mathematics Tasks as Aligned with the PISA Conceptual Framework

Abstract based on a detailed analysis by Zbigniew Marciniak and Agnieszka Sułowska

Beginning in 2018, the foundation approached research and development centers in Israel for the purpose of developing mathematics learning tasks that correspond to the PISA conceptual framework at the high levels (5-6). Over the course of four years, 500 such tasks were developed through 25 different programs — each addressing different perspectives and contexts of applied mathematics. The objective of this review was to examine the degree to which these tasks align with the PISA conceptual framework. The analysis was led by Prof. Zbigniew Marciniak, a mathematician and a former Polish education deputy minister who also served as the chair of the PISA assessment's mathematics expert group.

Main findings

1. Tasks were examined based on several criteria derived from the PISA assessment: level of mathematical reasoning and argumentation, the real-world context, mathematics level, range of mathematics topics, opportunities for learning, and didactic opportunities and challenges.

2. The tasks found to be the most aligned with the PISA 5-6 standards are those which were developed by the University of Haifa (MAOF), those developed by the Weizmann Institute of Science (Mahalachim and Think Far), and those developed by the Technion (Machshava) and Think.org.il (Practimatics).

3. Comments made with respect to other programs mostly pertained to tasks which were too closed-ended and led students to the solution, those with a low a level of mathematical reasoning and argumentation, or those which had errors. It was found that the level of the curriculum for distance learning, mostly in Arabic speaking schools did not meet the PISA assessment standards.

4. Tasks developed within a scientific context (chemistry, physics, biology, and computer sciences) naturally stress the scientific field. But it was found that they were not sufficiently explicit in their mathematical indices and were not integrated at a high enough level.

5. In summary, about half of the tasks examined encourage mathematical reasoning and argumentation. There is another 10% of tasks whose correspondence to PISA can be enhanced without much effort. The researchers recommend integrating the opportunity for mathematical reasoning and argumentation in each and every task.

6. Only about half of the tasks encourage joint thinking processes, class research and discussion, and a similar proportion deepen mathematical skills. The researchers recommend that the developers abandon the classical textbook tasks model and develop more challenging and open-ended tasks.

7. The way mathematics is integrated in science tasks does not enable deep understanding of mathematics and can produce misconceptions. In such cases, the researchers recommend explicitly presenting the mathematical concepts and tools.

8. The tasks dealing with geometry are those which, in the researchers' opinion, summon the best opportunities for developing reasoning and argumentation thinking and skills. The researchers recommend that the developers increase the weight and scope of geometry tasks.

Core Teaching Practices for Applied Mathematics

An abstract based on a study by Talli Nachlieli, Michal Ayalon, Boaz Zilberman, and others

A team of researchers in the field of mathematics education observed lessons and conducted in-depth interviews with teachers who teach high order applied mathematical thinking in middle school classes. The goal of the research was to identify core pedagogic practices common to these teachers and to jointly articulate those shared teaching practices. As part of formulating the core practices, the research team studied similar efforts made in recent years in Israel and around the world.

Core teaching practices

1. Insisting on clear and explicit expression. The teacher demonstrates and expects the students to formulate concepts, processes, and arguments in a precise and clear manner. There is strict adherence to definitions, rules, reasons, justifications, and proofs of claims in writing and orally and in joint discussion.

2. Creating links between representations, ideas, and contexts. The teacher chooses tasks in which the students must cope with a problem which does not have a known procedure for resolution. The task requires comprehension of context, in-depth use of concepts and planning different solutions using diverse mathematical representations.

3. Engaging students in dialogue. Formal discourse between students takes place in class where they are expected to express ideas, relate and understand each other's complex arguments, to put forward claims, to cast doubt, and to convince one another.

4. Sharing pedagogical considerations with the students. The teacher reveals to the students the considerations that went into selecting the task and the teaching method chosen. The teacher shares with the students the dilemmas, alternatives, stages, expectations, and method of structuring the lesson and the mathematical discourse.

5. Designing a safe environment for emotions. The teacher allows students to be brave and to be fearful, to experiment, to explain their thinking, to receive feedback, to make a mistake and to learn from it and to reveal prejudices.

6. Analyzing and reflecting the lesson. Following the lesson, the teacher (alone and with colleagues) uses documentation that was captured during the lesson. The objective of this process is to develop expertise, to perfect teaching technique, and contribute to the shared advancement of the professional community.

Teaching Applied Mathematics: Feedback from Teachers

An abstract based on interviews by Nitzhia Peleg

In recent years, at the initiative of the Trump Foundation, academic organizations across the country have developed learning materials, which incorporate modelling and reasoning tasks into mathematics lessons in alignment with the international PISA assessment's 5-6 proficiency levels. 1,300 mathematics teachers participated in dedicated professional development (in-service education and communities of learning) and gained experience teaching the new tasks in their classrooms. The aim of this qualitative study was to obtain in-depth feedback from teachers regarding the teaching and learning experience, to learn about the opportunities and difficulties, and to recommend improvements.

Main insights

1. Many teachers expressed great enthusiasm concerning the link between mathematics and the real world to illustrate to students the importance and relevance of mathematics to life. They believe that this makes mathematics more sophisticated, more interesting, and more mysterious.

2. The teachers emphasized the centrality of the national curriculum and noted that they are committed to it and orient their effort toward it. As a result, they select tasks that correspond spirally with curriculum topics, as preparation for, or as an application of, a topic or mathematical concept that is defined in the curriculum.

3. The teachers brought up the insight that teaching applied mathematics requires a great deal of preparation and classroom time, and much use of technology. They recommend devoting the required resources to these aspects.

4. Teaching modelling and reasoning tasks characterized by uncertainty, multiple solutions, and transition between mathematics and real-world context arouses feelings of lack of confidence among the teachers. They note that normally, they are completely conversant with the material and stepping out of their comfort zone to unfamiliar material undermines their confidence.

5. The teachers noted that to teach applied mathematics well, they need close instructional coaching, discussion with colleagues in a community of learning, and technology training. They are interested in having the ability to choose the tasks and adapt them to their specific circumstances in the classroom.

6. The teachers report that their students enjoy learning applied mathematics very much. They succeed in connecting between topics, they upgrade their grasp of mathematics, understand things by themselves, they begin to use mathematical language, and express motivation that stems from understanding the relevance.

7. On the other hand, students are required to focus for longer periods. They express their difficulty with the linguistic layer of reading comprehension. The transition from passive learning to independent learning has sometimes led to them giving up

Excellence in Middle School — A Survey of Parents and Students

An abstract based on survey findings by *Midgam*, August 2022

Following a media campaign in collaboration with ***Keshet***, which focused on promoting excellence in middle school, we turned to the ***Midgam*** Research Group to conduct a survey among parents and students. The purpose of the survey was to identify whether over time, and as a result of the campaign, changes in parents' and children's thinking patterns and behavior have been taking place. Earlier surveys showed that middle school is perceived as a less important stage from an academic standpoint and that there is a very low level of awareness of the option of choosing excellence tracks already at this stage.

Main findings

1. In response to the question what is the first priority for students in middle school? 51% of the parents said, "investing in learning" and 25% responded "social life." Among students, the perceptions were reversed with 52% believing that social life is the most important and just 36% replying "studies". However, among students in excellence classes and the top ability group in mathematics, the perceptions were similar to those of the parents.

2. Both parents and students say that English and mathematics are the most important subjects (about 70%), and there is a substantial disparity between those two and all the other subject areas (the next in line was roughly 10%).

3. Most parents and students believe that studies in high school are the most important stage. This is followed by a significant gap, by studies in university and only then, in middle school (parents — 14 %, students — 11%).

4. The parents report that they are the ones with the greatest impact on their children's degree of investment in middle school studies (75%). The children also believe that their parents have a very high degree of influence (80%).

5. Even after the media campaign, only 53% of parents and students had heard about the existence of middle school excellence tracks. About 40% claim that there are no such tracks in their school. Among those who are familiar with these tracks, the most familiar program is Mofet (12%).

6. To the question of "for what purpose?" should one study in an excellence track, parents and students agree that the main reason is "to develop thinking abilities" (parents — 63%, students — 48%). When asked to provide additional important reasons, a significant gap between parents and students was revealed:

- **a.** Parents cited pedagogical and social reasons, such as "to study in a class with good students" (45%), "to study interesting topics" (42%), and "to study with good teachers" (35%).

- **b.** Students mentioned these topics but along with them cited utilitarian reasons (which parents also mentioned but in lower numbers), such as "a better future" (45%) and "a higher salary" (39%).